

Hurricanes and Extratropical Cyclones

Chapter 10

Learning Objectives

- Understand the weather conditions that create, maintain, and dissipate cyclones
 - Understand the difficulties in forecasting cyclone behavior
 - Know what geographic regions are at risk for hurricanes and extratropical cyclones
 - Understand the effects of cyclones in coastal and inland areas
 - Recognize linkages between cyclones and other natural hazards
 - Know the benefits derived from cyclones
 - Understand adjustments that can minimize damage and personal injury from coastal cyclones
 - Know the prudent actions to take for hurricane or extratropical cyclone watches and warnings
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Look at Hurricane Sandy

- Hurricane Sandy Deaths – 125 people; 60 in New York: 48 in New Jersey: 16 Pennsylvania; 7 In West Virginia; and 71 in the Caribbean
 - Economic Losses -- \$62 billion – second costliest storm in US history after Katrina which caused \$128 billion –caused \$315 billion in the Caribbean before hitting the US
 - Total Damage caused – 72,000 homes or business in New Jersey alone, in Cuba estimated 130,000 to 200,000 homes damaged or destroyed
 - Disaster Aid requirement – New York -- \$42 billion with \$9 billion for future damage prevention , New Jersey -- \$37 billion with \$7.4 billion for future damage prevention
 - Hurricane Sandy's Magnitude – tropical force winds extended 820 miles at their wide, pure kinetic energy for storm surge and wave “destruction potential” reached a 5.8 on a scale of 0 to 6 scale, the highest measured
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Collision of Hurricane Sandy & Nor'easter



Flooded Neighborhood in New Jersey After Sandy



Fire Damage in Queens, New York after Hurricane Sandy



Introduction to Cyclones

- Atmospheric cyclones -- *classified on their place of origin*
 - Extra-tropical cyclones – *Mid-latitude cyclones on a westerly waves*
 - Found “outside the tropics” - *extra*
 - Between *30 and 70 degrees latitude*
 - Associated with fronts and cool central cores
 - Characterized by their cyclone intensity which indicates their *sustained wind speeds and lowest atmospheric pressure*
 - These types of storms cause strong windstorms, heavy rains and surges of rising seawater on both the West and East Coasts
 - During cooler months they create *snowstorms and blizzards*
 - Can produce outbreaks of tornadoes and severe thunderstorms especially east of the Rocky Mountains in the U.S and Canada
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Introduction to Cyclones

- Tropical cyclones –on easterly waves
 - Found over warm tropical or subtropical ocean water
 - Between 5 and 20 degrees latitude
 - Include tropical depressions, tropical storms, and hurricanes
 - These three types of tropical weather systems create high winds, heavy rain, surges of rising seawater, and tornadoes
 - Both Extratropical and Tropical cyclones have a counter-clockwise circulation pattern in the Northern Hemisphere and clockwise in the Southern Hemisphere because of the **Coriolis Effect**
 - Cyclones rarely form below the 5 degrees because of the weak Coriolis effect
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Two Types of Cyclones

- Cyclones
 - Although both of these types of cyclones can have destructive effects, *they differ in the source of energy and structure*
 - Tropical cyclones get their energy from the warm ocean water and latent heat released as rising air condenses to form clouds
 - ❖ Warm air rises to form a spiraling pattern of clouds
 - ❖ The rising and warming air surrounding the center, and heats the entire core of the core
 - ❖ When these storms move over land or cooler water, they lose their original source of heat
 - ❖ They either dissipate or become extratropical cyclones moving along a front
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Two Types of Cyclones

- Extratropical cyclones

- Extratropical cyclones obtain their energy from the horizontal temperature contrast between the air masses on either side of a front

- ❖ They are fed by cold air at the surface and another flow of cool, dry air aloft.

- ❖ The resulting storm has a cool core from bottom to top

- We will learn more about Extratropical cyclones later in the chapter

Naming Tropical Cyclones

- Naming Convention –
 - The classification and naming is often debated because of the science, custom, and politics
 - Extratropical Cyclones are not usually given a personal name
 - Tropical Cyclones are given names as they develop and there is a naming convention.
 - ❖ Naming of individual cyclones began in the 1940's
 - ❖ Once the winds reach a sustained maximum wind speed of 39 mph, it is given a name
 - These names come from a previously agreed on list for each year, starting with the letter a in the alphabet
 - These alternate men and women's names from English, Spanish, and French
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Classification of Tropical Cyclones

- **Classification:** for meteorologists' *cyclone is term for the large low-pressure system*
 - **Hurricanes have many classifications or names depending where you are in the world. These are:**
 - ❖ *Typhoons in the Western Pacific area*
 - ❖ *A variation of cyclone in the Southern Hemisphere and in the Indian Ocean*
 - **Hurricanes are classified by their wind speed. There are 5 levels.**
 - ❖ *Category 1 -- 74 to 95 mph*
 - ❖ *Category 2 – 96 to 110 mph*
 - ❖ *Category 3 – 111 to 130 mph*
 - ❖ *Category 4 – 131 to 155 mph*
 - ❖ *Category 5 – 156 to -----*
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How are and Where do Hurricanes Form?

- Tropical Cyclones

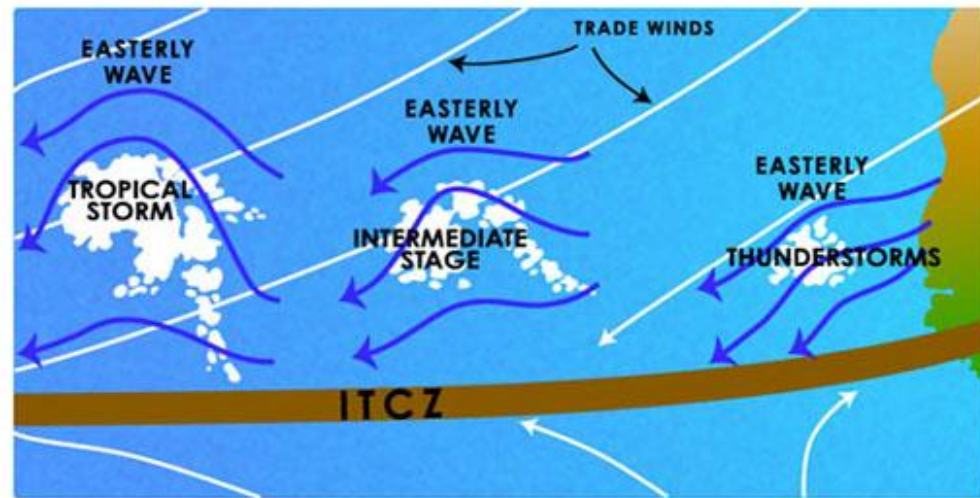
- Form only over warm oceans in the tropics at least a between 5 to 20 degrees north or south of the equator depending on location
- Mechanism of formation not fully understood
- Always develop out of a preexisting tropical disturbance in the tropical troposphere.
- Easterly waves provide low-level convergence and lifting that catalyze the develop
- Less than 10% of all easterly waves grow into hurricane

- Movement

- Stays within the trade-winds moving east to west



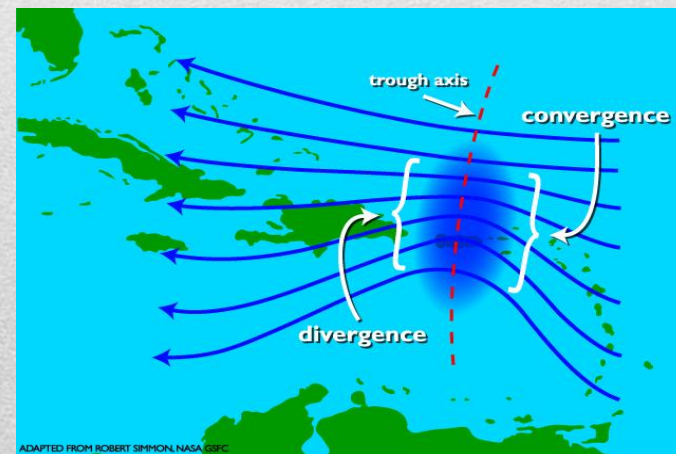
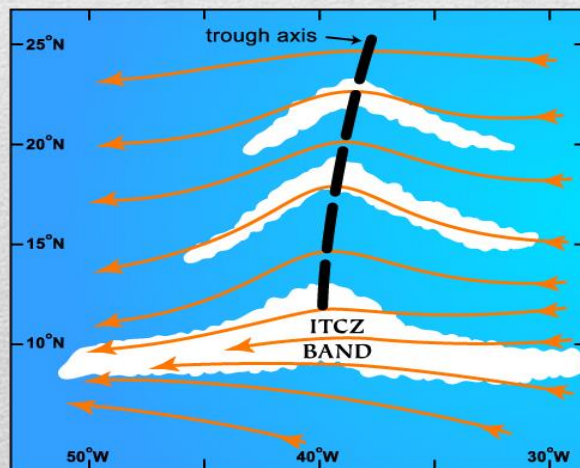
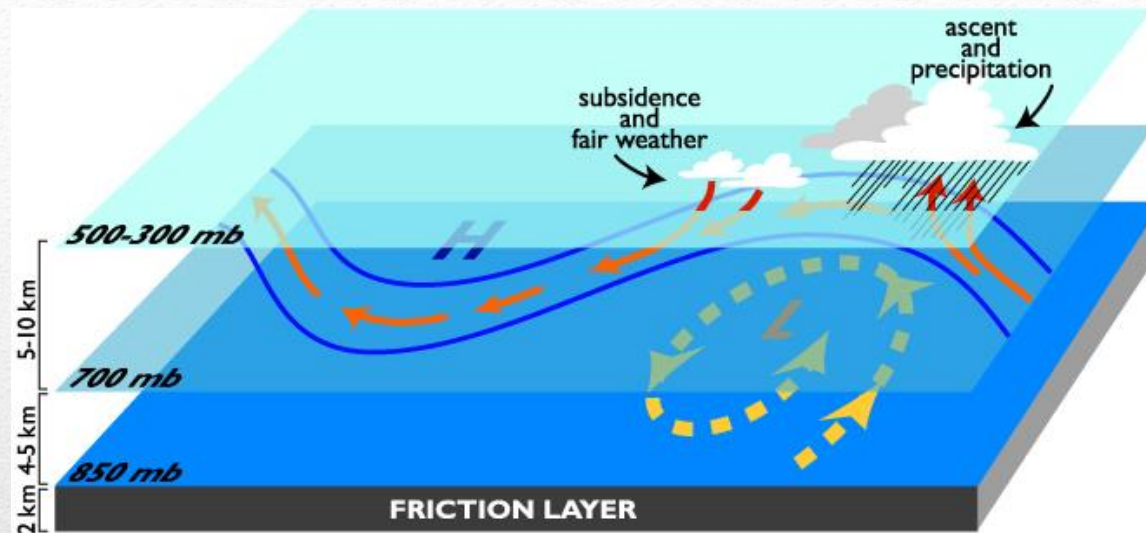
How are and Where do Hurricanes Form?



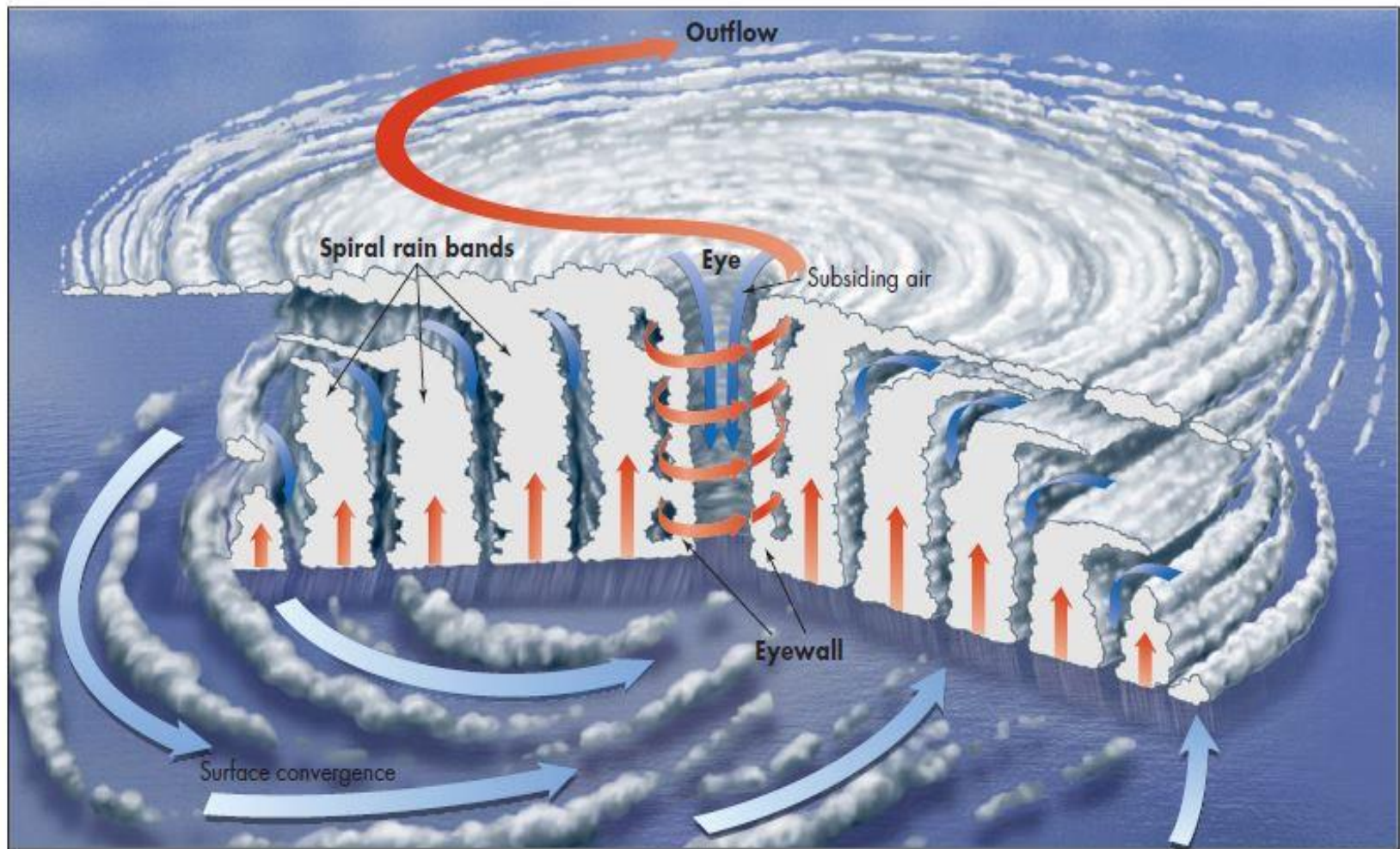
Tropical Cyclones

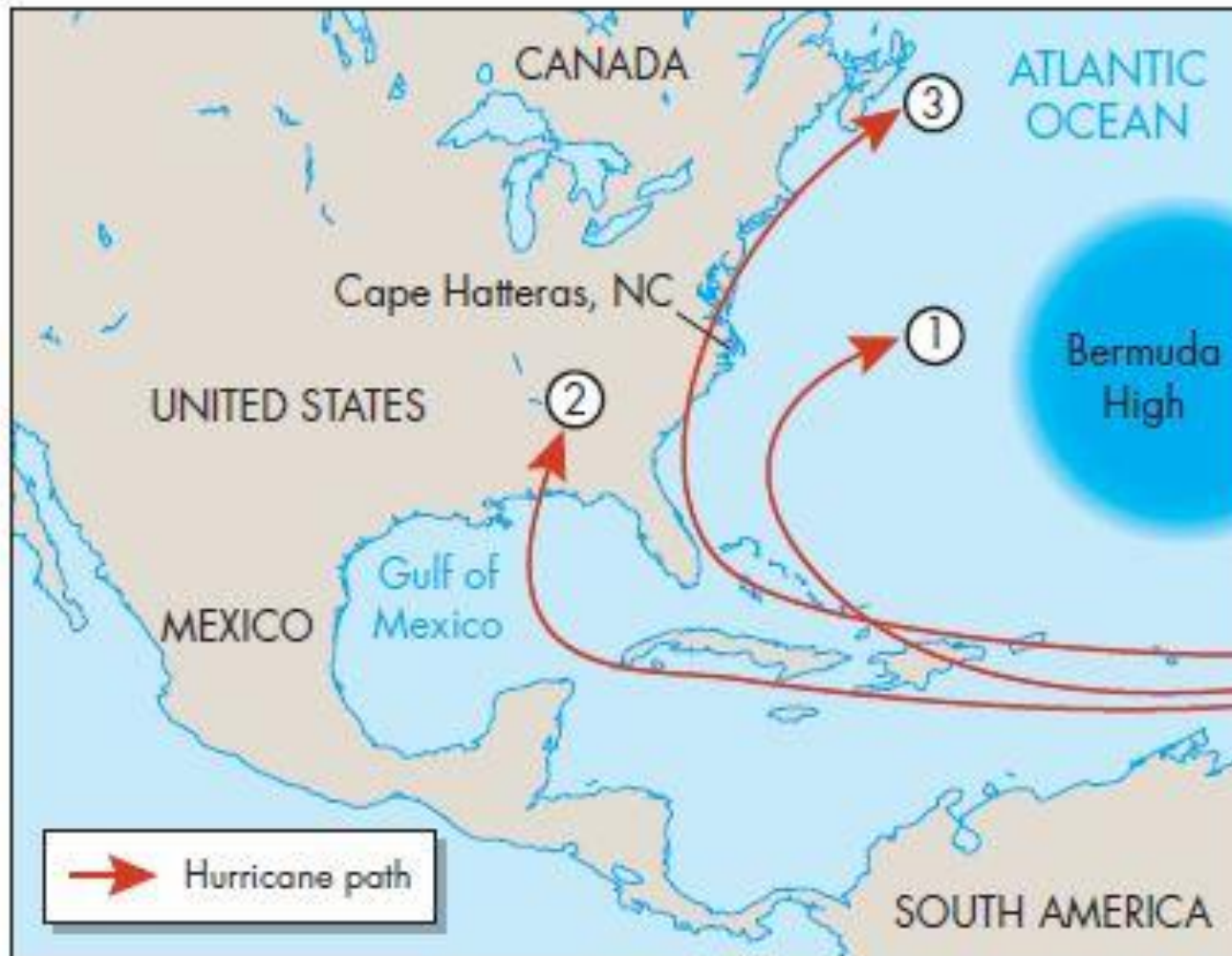
- Characteristics

- *Prominent low-pressure centers that are essentially circular with steep pressure gradient outward from the center*
 - *Converging cyclonic wind pattern “fuel” that powers the storm*
 - *Warm, water vapor-laden air spirals into a storm*
 - *Intense updrafts within towering cumulonimbus clouds*
 - *Eye of the Hurricane quiet, with spiraling walls of rain bands surrounding*
 - *Associated with strong windstorms, heavy rains, surges of rising seawater, and tornadoes*
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Parts of the Hurricane





Tropical Cyclone



Extratropical Cyclones

- Origin

- Two major ingredients contribute to the development of a Extratropical (Mid-latitude) cyclone

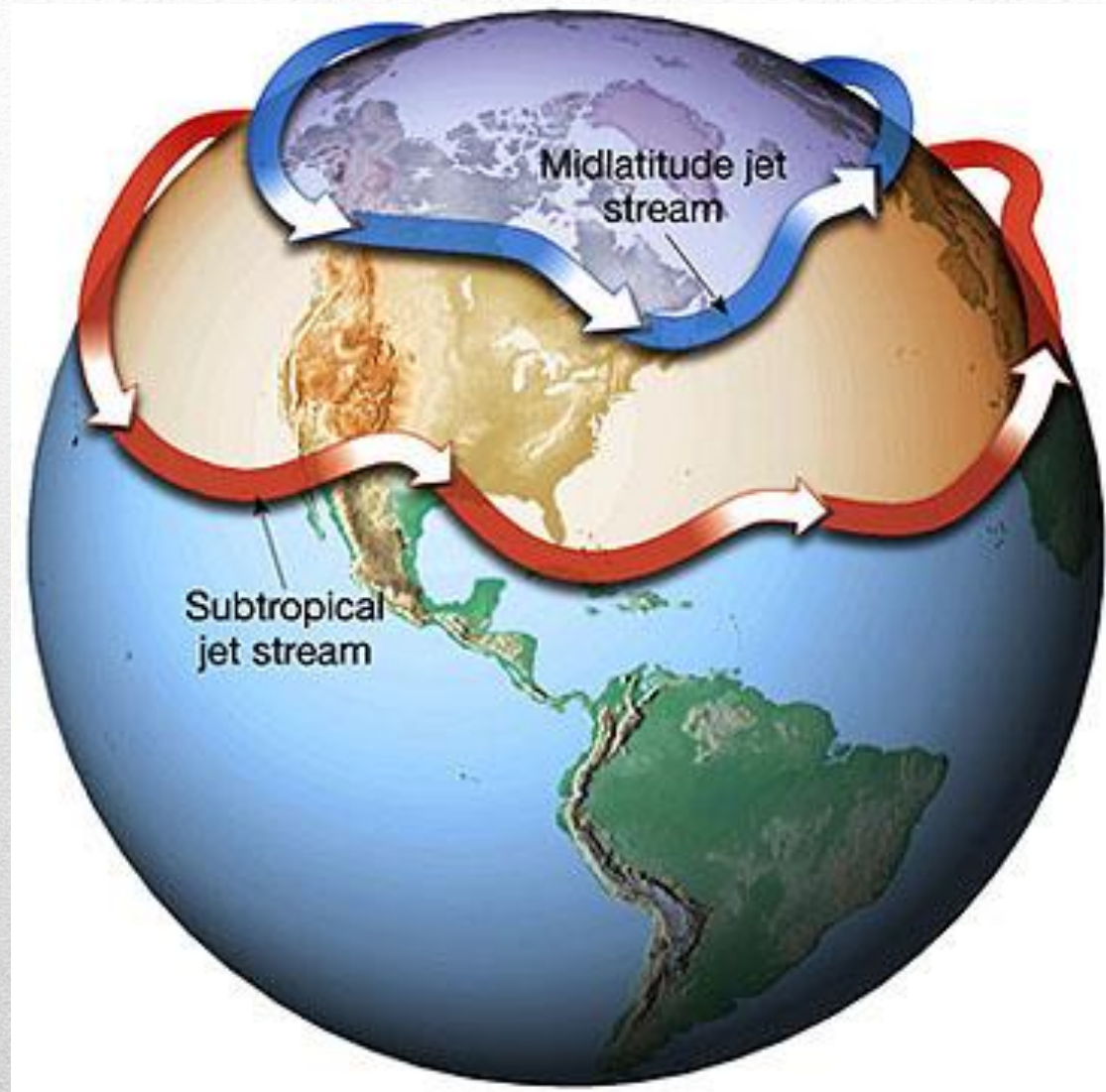
- ❖ A strong temperature gradient in the air near the surface

- ❖ Strong winds in the upper troposphere

- Found in the *Polar (Mid-latitudes) and Sub-tropical jet streams*

- ❖ Shifts northward and southward with the seasons

- Intensify when they cross areas with strong low-level temperature gradients



Extratropical Cyclones

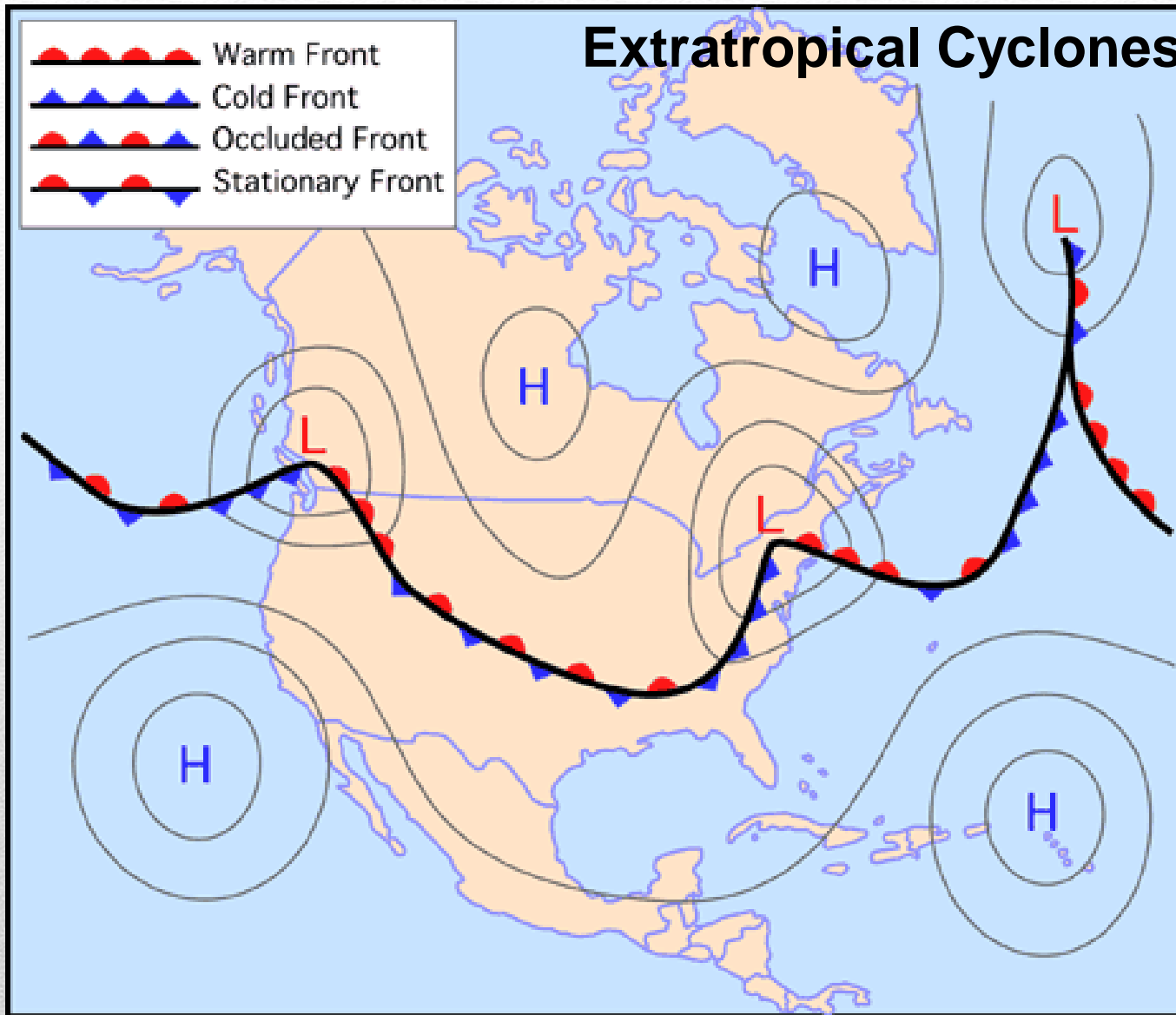
- Movements of Extratropical cyclones
 - Generally moves *west to east*, taking about *3 to 4 days to cross the U. S.*
 - System has a *cyclonic wind circulation with converging counterclockwise from all sides*
 - *Cold front normally advances faster than the storms moves swinging it counterclockwise around the pivot center increasingly moving and displacing the warm sector*
 - *Warm front usually advances more slowly than the storm*
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Characteristics of Extratropical Cyclones

- Characteristics

- Diameter – 1000 miles or so
 - Clear-cut pressure trough extends southwesterly from the center
 - Two fronts, warm and cold, with a cool sector north and west of the center and warm sector to the south and east.
 - Can cause **strong windstorms, heavy rains, and surges of rising seawater on both coasts**
 - During the winter- **associated with snowstorms and blizzards**
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Extratropical Cyclones

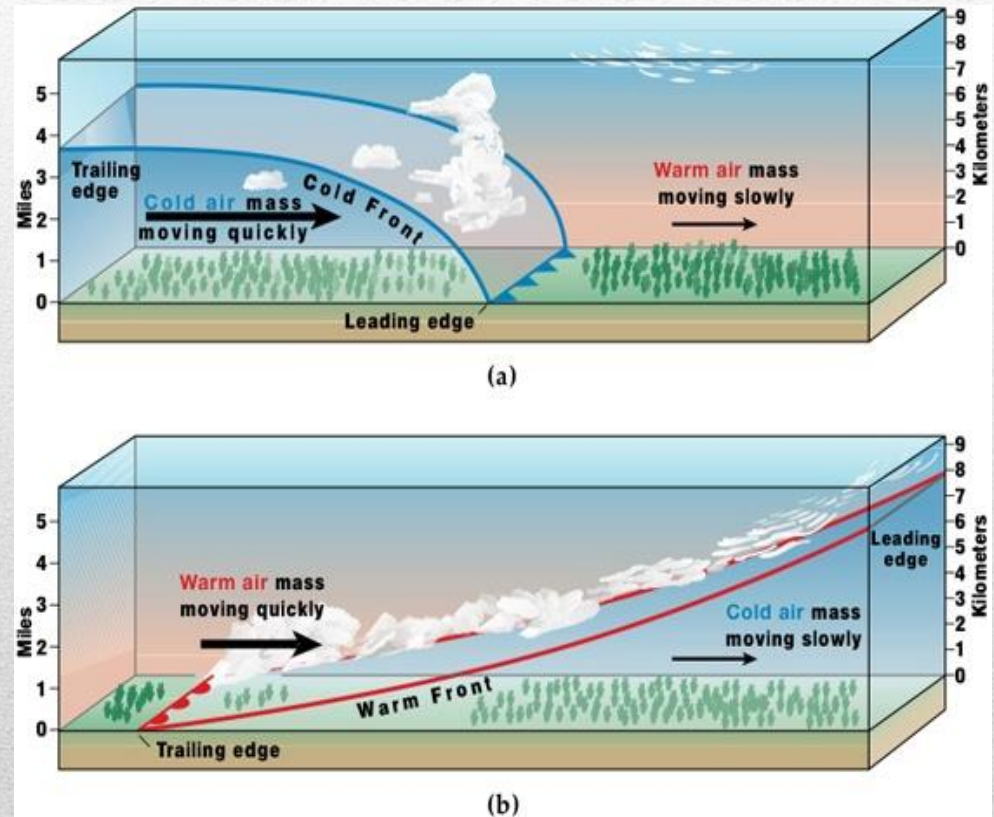


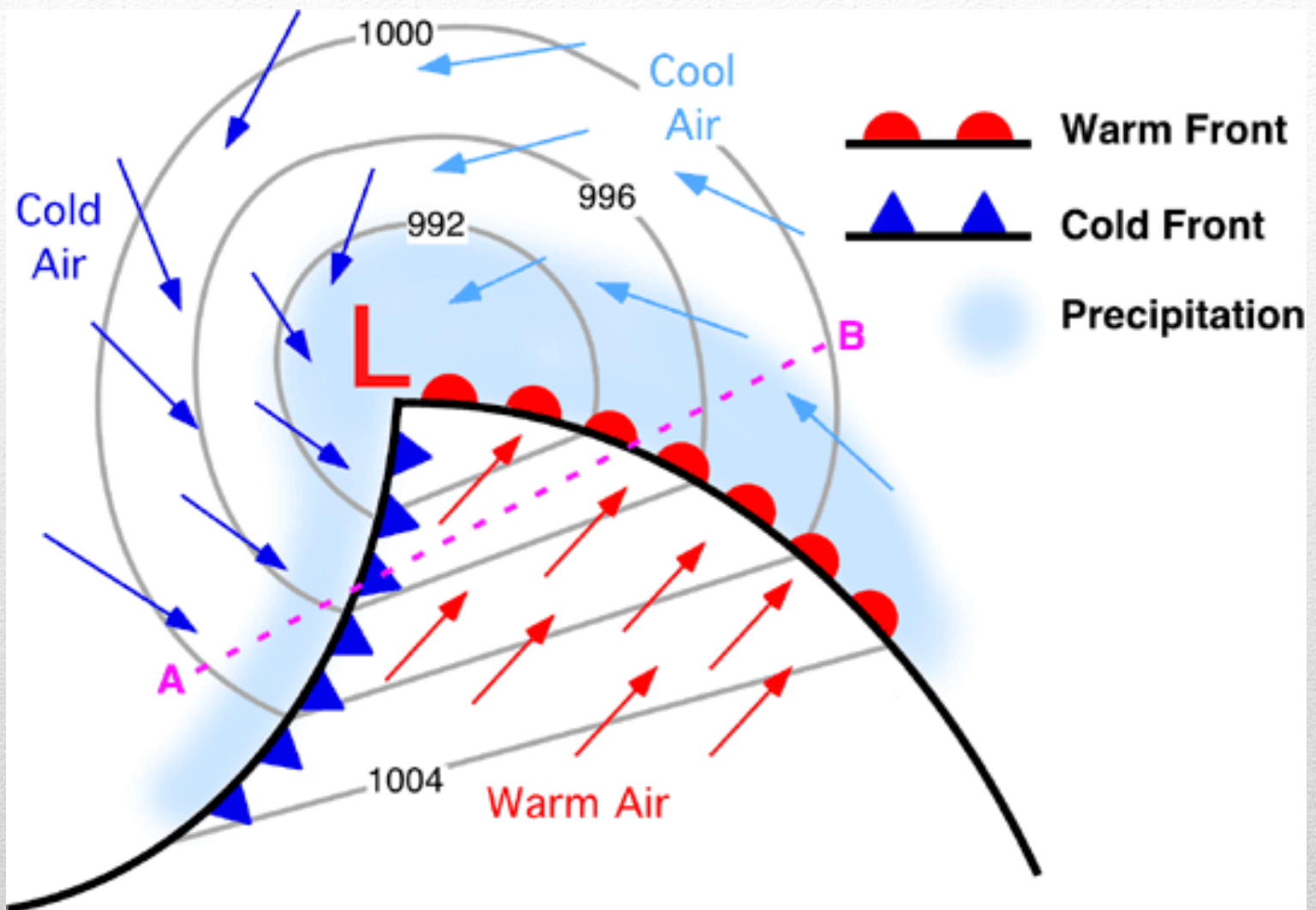
Warm and Cold Fronts

- Passing of the Warm and Cold Fronts
 - Temperature decreases sharply
 - Winds shift from southerly ahead of the front to the northwesterly flowing it
 - The front is in a pressure trough, so pressure falls as the front approaches and rises after it passes
 - Clear skies are replaced by cloudiness and precipitation of the front
 - Similar changes but to a lesser magnitude occur when the warm front passes
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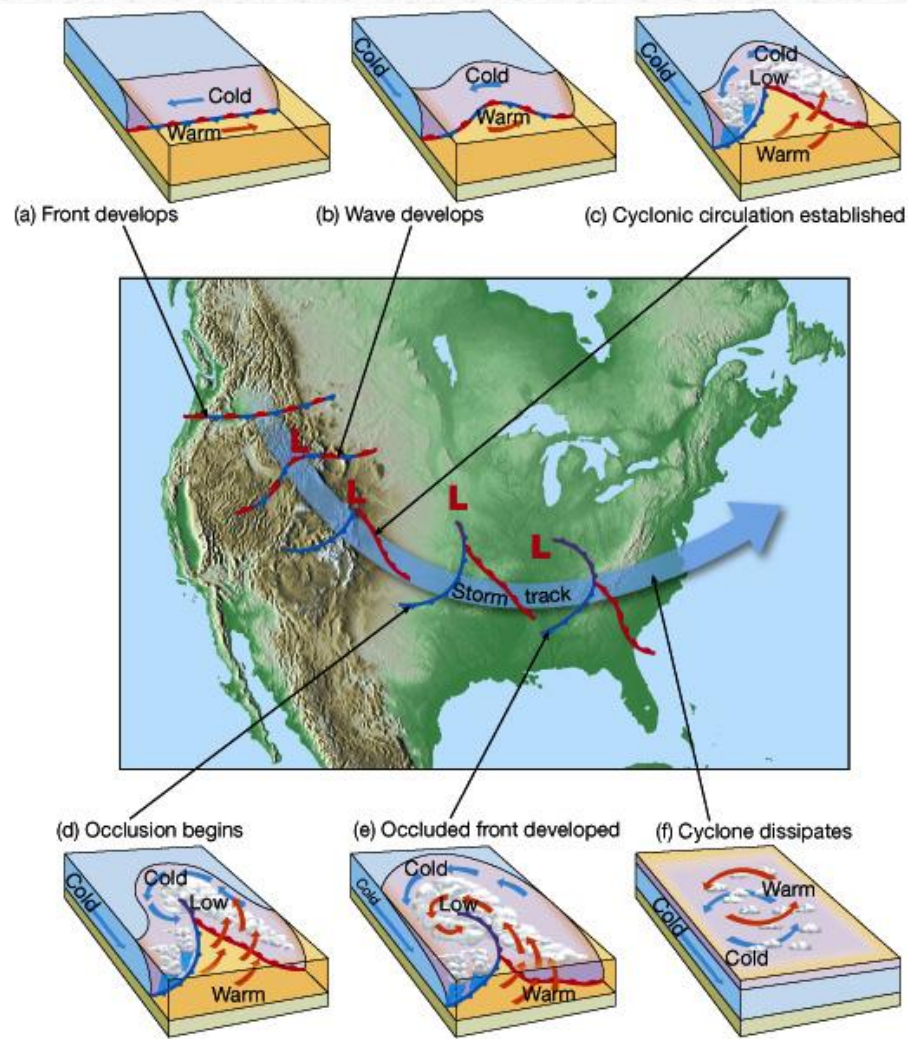
Fronts

- Boundary between a two unlike air masses
- Not two dimensional boundary at the surface, but a three dimensional zone of discontinuity
- Types of Fronts
 - Warm, Cold, Stationary, Occluded





Life Cycles of the Extratropical Cyclones

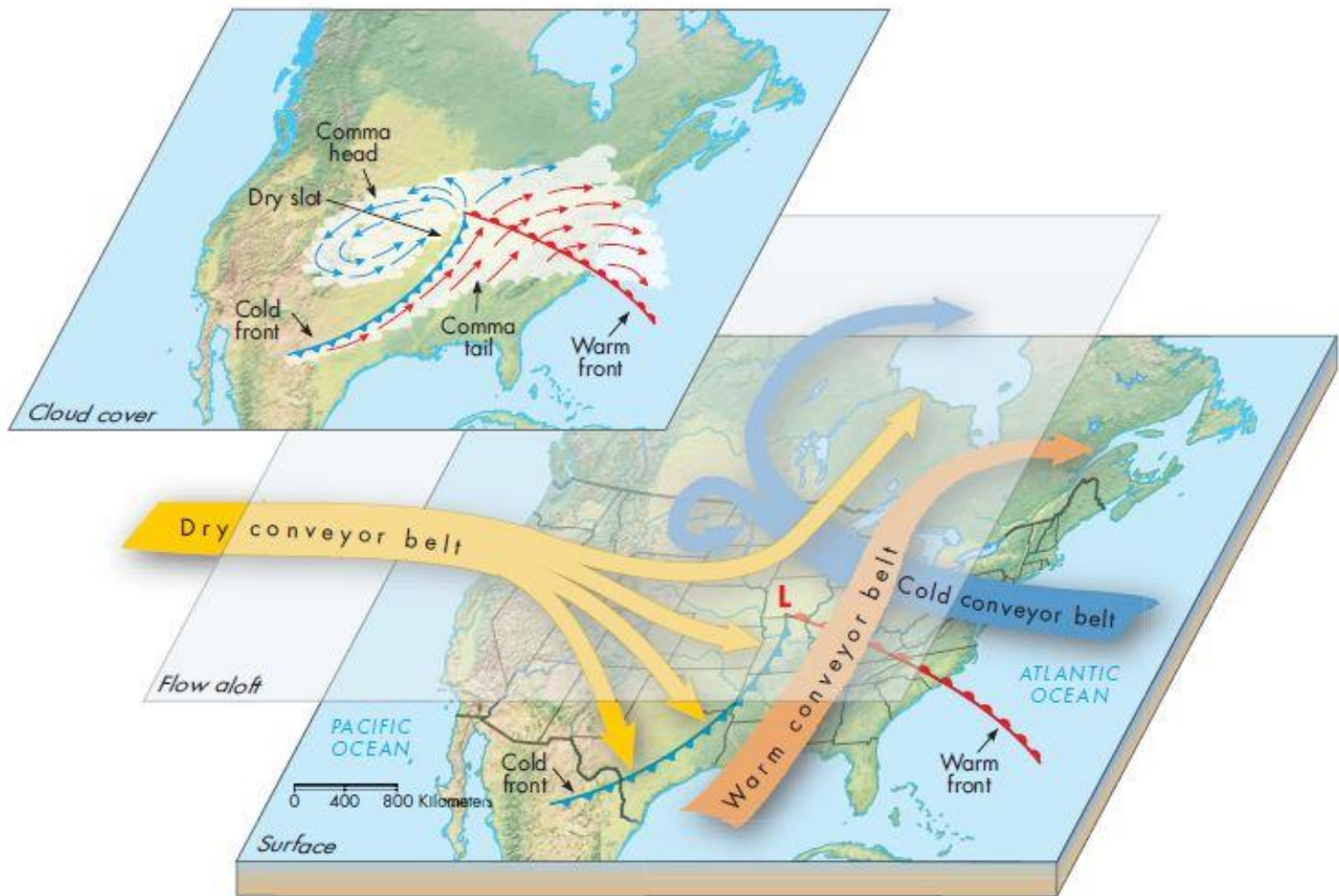


Remember this

Life Cycle of the Extratropical Cyclones

- Front develops
- Wave appears along the front
- Cyclonic circulation is well developed
- Occlusion begins
- Occluded front is fully developed
- Cyclone dissipates

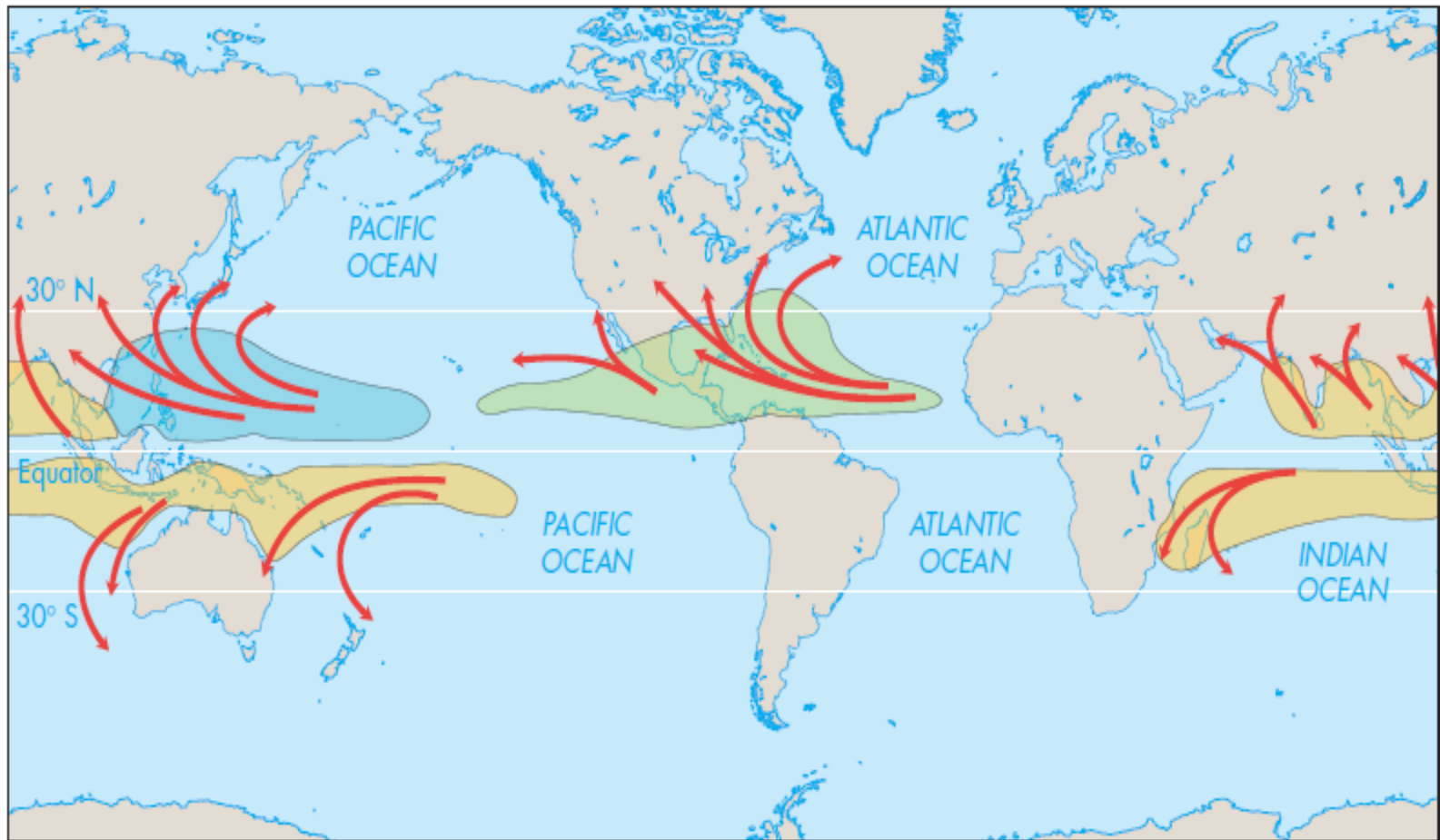
Remember this



Geographic Regions at Risk for Cyclones

- **Tropical and Extratropical Cyclones pose threats to different parts of the country**
 - **Tropical cyclones pose threats to these areas**
 - ❖ On the East Coast and the Gulf of Mexico and the Islands of the Caribbean Sea
 - ❖ On the West Coast and in the Pacific Ocean, Baja California. West Coast of Mexico and the Pacific Territories of the US
 - **Extratropical Cyclones pose threats to all parts of the US**
 - ❖ Anywhere in the US an Extratropical Cyclone can develop and can bring severe weather to all 50 states (including Hawaii sometimes)
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Typical Tropical Cyclones Paths



Effects of Cyclones

- Both types of cyclones claim many lives, cause enormous amounts of property damage, with flooding, thunderstorms, tornadoes, and in the winter, snowstorms and blizzards
 - Three effects are especially damaging:
 - *Storm Surge, High Winds, Heavy Rain*
 - *Storm Surge – the local rise of the sea level that results primarily from water that is pushed toward the shore by the storm winds*
 - ❖ Two mechanisms for storm surge are:
 - *Stress exerted by wind on the water surface causing the water level to rise*
 - *Low atmospheric pressure that sucks up the water surface*
 - ❖ Erosion is also caused by storm surge
 - *Beaches are eroded by huge waves*
 - *Homes along beaches are damaged or washed away by storm surge*
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Effects of Cyclones

- *High Winds – strong winds from both types of cyclones cause enormous amounts of damage.*
 - High winds blow over houses or damage them
 - High winds will blow over trees, telephone poles, signs, doing damage to anything underneath
 - High Winds are also responsible for more erosion of beaches by blowing away the sand
 - *Heavy Rains – Intense rainfall from cyclones can cause widespread inland flooding*
 - Flooding causes damages in houses and businesses
 - Erodes the beaches
 - Floods roads so evacuees can not get out of the way of the storm
 - In large cities, clogs drainages systems and creates havoc
 - *Hurricane Sandy when it combined with the Extratropical storm caused all of the problems*
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Hugh waves and tide from Storm Surge



Damage from High Winds



Getty Images

Flooding because of Heavy Rains



Linkages between Cyclones and other Natural Hazards

- **Coastal Erosion**
 - **Flooding**
 - **Mass Wasting**
 - **Tornadoes**
 - **Severe Thunderstorms**
 - **Snowstorms**
 - **Blizzards**
 - **Rising waters of the oceans devastating coastlines**
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Natural Service Functions of Cyclones

- *Storms influence our lives everyday*
 - *Storms impact the landscape*
 - *Negative effect*
 - ❖ Accelerate erosion,
 - ❖ Flood valleys,
 - ❖ Destroy buildings
 - ❖ Decimate crops
 - *Positive effect*
 - ❖ Promote diversity in vegetative cover
 - ❖ Increase the size of lakes and ponds
 - ❖ Stimulate plant growth with moisture
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Natural Service Functions of Cyclones

- Primary Source of precipitation
 - Equalizing temperatures
 - Storms carry plants, animals, and microorganisms to volcanic islands bringing the flora and fauna
 - Winds stir up the waters of the ocean bringing nutrient rich plankton to the surface
 - View cyclones as awe-inspiring sources of beauty and reminders of the power of natural processes
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Minimizing the effects of Cyclones

- Forecasts and warnings

- Hurricane forecasting tools

- ❖ *With the invention of Global Positioning Systems (GPS) and accurate Geographic Information Systems (GIS) hurricanes can be tracked and people can be warned about storm and “get out of the way”*

- ❖ *Weather Satellites are also essential to the forecasting of these storms*

- *Meteorologists use computers to develop weather models from the data collected by the weather satellites or GPS units to create a better forecast*
 - *Hurricane watches and warnings can be given, enabling people time to prepare for the storm*
 - *Storm watches and warnings are given for Extratropical cyclones. This allows for people across the country to prepare for a storm*
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Human Interaction with Cyclones

- *Can't Fix Stupid!*
 - More people are building close to the shores
 - Many are building their homes in mountainous places where there is chance of sliding if there is a large wet storm
 - Looking at the destruction of both Katrina and Sandy, we can see how people were not prepared for these storms
 - But they are learning.
 - ❖ *People are slowly rebuilding New Orleans and Long Island*
 - ❖ *They are building smarter and trying minimize damage from future storms*
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Human Interaction with Cyclones

- Actually with the invention of *Global Positioning Systems (GPS)* and *accurate Geographic Information Systems (GIS)* hurricanes can be tracked and people can be warned about storm and “get out of the way”
 - As the *population grows in the US and around the world*, more people are effected by these kinds of storms
 - The *better the tracking systems and forecasting*, the less people get hurt of killed.
 - The *more we know about these storms*, the better we can build our houses to withstand these storms.
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Minimizing the effects of Cyclones

- Forecasts and warnings

- Using new imagery called LiDAR, forecasters can predict storm surge.

- ❖ This new imagery shows a 3-D depiction of waves.

- ❖ This can help to warn people ahead of time about what kind of weather to expect

- Hurricane Prediction and the Future

- Since better prediction of hurricanes have been developed, less people have been hurt and/or killed

- But coastal populations are still growing and as long as this keeps happening there will be problems when these giant storms due occur

Perception of and Adjustment to Cyclones

- Perception of Cyclones
 - Residents who live in areas where there is a chance of hurricanes and/or large extracyclones have a large amount of experience with these storms, but they still seem to forget.
 - They don't seem to remember from year to year the risk from these storms
 - They really need to figure it out.
 - Adjustment to Hurricanes and Extratropical Cyclones
 - Warning systems, evacuations plans and shelters, insurance, and building design are key adjustments to these storms
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